Integrated weed management in the cotton farming system: why should the industry adopt this approach?

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Summary

Changes to the cotton farming system over the last decade have caused a change in the weed spectrum, favouring glyphosate tolerant, small seeded, biannual and perennial weeds. Management of these weeds in a minimum tillage system relying increasingly on glyphosate is problematic. Adoption of a proactive, integrated weed management system that focuses on reducing the weed seed bank by using a variety of tools will be necessary to maintain the system and ensure the future value of glyphosate in the farming system.

Introduction

Over the last two decades, the Australian cotton production system has undergone a series of changes. These include the widespread use of genetically modified, insect tolerant varieties (Ingard® and Bollgard II®), the adoption of reduced tillage, permanent wheel tracks and stubble retention, over-the-top, post-emergence herbicides, and the use of genetically modified, glyphosate tolerant (Roundup Ready®) cotton varieties, together with reductions in the use of hand hoeing and residual herbicides.

These changes have impacted on the density and diversity of weeds found in the farming system, reducing the importance of some weeds, and favouring other species. While the overall change have been beneficial, many cotton growers are moving towards farming systems that rely heavily on glyphosate. The potential threat of glyphosate resistance and the need to better manage weeds using an integrated weed management approach are issues being faced by the cotton industry.

Surveys

Surveys of weed density and diversity were undertaken in 1992, 1996 and 2001 on irrigated cotton fields on 19 properties in the Gwydir and Macintyre valleys. Surveys were conducted in early summer each year. Where possible, the same fields were surveyed, with up to 4 fields observed on each property. Surveys consisted of two transects per field, with a minimum of 10 observations per transect, each of 50 m^2. Information on grower's most problematic weeds was also collected in 1989, 1996 and 2001.

Weeds present in the cotton system

Changes to the cotton farming system over the last decade have resulted in an overall improvement in weed control on the surveyed properties (Table 1), with a reduction in the average weed density from 1.84 weeds m^{-2} in 1992 to 0.51 weeds m^{-2} in 2001.

A wide range of species were observed in the surveys, with a total of 54 different species identified over the 3 surveys. Most of these species occurred at relatively low densities on most fields. In addition, most of the annual grass species were not individually identified.

Table 1. Weed density and ranking of the 20 most numerous weeds. Data were averaged over 19 properties.

	1992		1996		2001	
		no. m^{-2}		no. m^{-2}		no. m^{-2}
1	Burr medic	0.38[T]	Bladder ketmia	0.56	Cow vine	0.17[T]
2	Cow vine	0.27[T]	Cow vine	0.35[T]	Bladder ketmia	0.10
3	Annual grasses[1]	0.23	Ryncho	0.20[TC]	Nutgrass	0.08[TC]
4	Bladder ketmia	0.16	Nutgrass	0.13[TC]	Barnyard grass	0.04
5	Sesbania	0.13	Annual grasses[1]	0.07	Rhyncho	0.03[TC]
6	Noogoora burr	0.10	Sow thistle	0.04[TC]	Emu foot	0.02[TC]
7	Mint weed	0.08[C]	Aust. bind weed	0.04[TC]	Bladder ketmia	0.01[T]
8	Thornapple	0.08	Cotton	0.02[T]	Wild gooseberry	0.01[C]
9	Wild gooseberry	0.08[C]	Wild gooseberry	0.01[C]	Thornapple	0.008
10	Emu foot	0.07[TC]	Caustic weed	0.01[C]	Sensitive weed	0.008[TC]
11	Yellow vine	0.06	Dwarf amaranth	0.007[C]	Aust. bind weed	0.008[TC]
12	Dwarf amaranth	0.04[C]	Sesbania	0.003	Annual polymeria	0.007
13	Ryncho	0.04[TC]	Thornapple	0.003	Sow thistle	0.004[TC]
14	Devil's claw	0.03	Yellow vine	0.003	Sesbania	0.004
15	Nutgrass	0.03[TC]	Maloga bean	0.002[TC]	Noogoora burr	0.003
16	Annual polymeria	0.01	Devil's claw	0.002	Dwarf amaranth	0.003[C]
17	Polymeria takeall	0.01[T]	Downs nutgrass	0.002[TC]	Pin sida	0.003[C]
18	Caustic weed	0.009[C]	Anoda weed	0.001	Mint weed	0.002[C]
19	Aust. bind weed	0.007[TC]	Polymeria takeall	0.001[T]	Downs nutgrass	0.002[TC]
20	Bathurst burr	0.007	Fleabane	0.001[TC]	Pig weed	0.002[C]
	Total weed density	1.84		1.50		0.51

Note[T]. Weeds that have a naturally high level of tolerance to glyphosate.

Note[1] Annual grasses, excluding barnyard and liverseed grass.

Note[C]. Small seeded, biannual and perennial weeds that are favoured by a reduced tillage system.

Burr medic, the most numerous weed in 1992 was rarely observed in the 1996 and 2001 surveys. This weed was present primarily on single fields on four properties. Two of these fields were newly developed from grazing country, explaining the presence of burr medic, but there is no apparent explanation for its presence at relatively high densities on the other two fields as both had a history of cotton cropping.

The reduction in density of some weeds such as sesbania and yellow vine can be related directly to the introduction of Staple in 1996. This herbicide is effective in controlling early season germinations of a range of weeds, but is less effective for controlling successive germinations as it can only be used twice in a season.

The largest influence on weed succession has been the adoption of permanent beds, with a corresponding reduction in cultivation passes and an increase in glyphosate use. This is particularly so in the fallow phase, where many cultivation passes have been replaced by herbicide applications. By 2001, all but one of the surveyed properties was using permanent beds, with stubble either retained on the soil surface or incorporated.

Management inputs

The use of in-crop inter-row cultivation and herbicide applications in conventional (non-Roundup Ready) cotton has changed little over the decade. The average number of inter-row cultivations on the surveyed properties declined from 3.3 to 2.8 per season, while hand hoeing passes declined from 1.4 to 1 per season (Table 2).

Table 2. Comparison of pre- and in-crop herbicide applications in 1989 and 2001. Data were averaged over 19 properties in the Gwydir and Macintyre valleys .

Herbicides	1989		2001		Herbicides	1989		2001	
	Rate (a.i.)	% farms	Rate (a.i.)	% farms		Rate (a.i.)	% farms	Rate (a.i.)	% farms
Pre-planting residual					At-planting non-residual				
trifluralin	1.1	49	1.0	42	glyphosate			0.7	17
pendimethalin	0.9	8	1.3	8	Post-emergence				
metolachlor			2.1	8	Roundup Ready			3.0	25
Total grass		57		58	Staple			0.06	8
fluometuron	0.8	14	1.5	8	Lay-by residual				
diuron	1.2	22	1.3	50	fluometuron			1.0	8
Total broadleaf		33		58	fluometuron + prometryn	1.3	11	0.9	17
At-planting residual									
pendimethalin	1.0	24	0.8	33	prometryn	1	18	1.5	17
metolachlor	1.7	15	0.7	8	diuron	1.2	36	1.1	33
Total grass		43		42	MSMA	1.6	4		
fluometuron	1.3	54	1.5	25	Total broadleaf		67		67
fluometuron + prometryn	1.8	38	1.5	67					
diuron	1.1	49							
Total broadleaf		92		92					
Inter-row cultivation passes	3.3		2.8		Hand hoeing passes	1.4		1.0	

There has been almost no change in the use of residual herbicides in crop, although 25% of properties were using Roundup Ready cotton, with three in-crop applications of glyphosate in addition to their conventional herbicide program.

The increase in glyphosate use and reductions in cultivation (mainly in the fallow phase) have lead to a relative increase in the density of glyphosate tolerant, small seeded, biannual and perennial weeds. Weeds such as nutgrass, sow thistle, Australian bind weed, rycho and native sensitive weed have all increased in importance over the decade.

By 2001, 14 of the 20 most numerous weeds of cotton were either glyphosate tolerant, or favoured by reduced cultivation or both (Table 1). Weeds such as sow thistle and fleabane are becoming troublesome in many minimum tillage systems that rely heavily on glyphosate. Volunteer crop plants from previous crops are also becoming more troublesome, particularly in fields where the use of residual herbicides has been reduced. The build up of glyphosate tolerant weeds and crop volunteers threatens the future value of glyphosate in the farming system.

Problem weeds

In addition to the physical surveys that reported weeds not controlled at the time of the surveys, cotton growers were asked which weeds were the most troublesome in their farming system. These were the weeds they were actively controlling in fields and were not necessarily detected at high densities in the surveys (Table 3).

Table 3. The 15 most troublesome weeds of cotton in order of priority, averaged over 19 properties.

	1989	1996	2001
1	Cowvine	Nutgrass	Cowvine
2	Noogoora burr	Cowvine	Noogoora burr
3	Yellow vine	Wild gooseberry	Bladder ketmia
4	Wild gooseberry	Yellow vine	Sesbania
5	Bladder ketmia	Ryncho	Wild gooseberry
6	Polymeria takeall	Bladder ketmia	Thornapple
7	Devil's claw	Devil's claw	Nutgrass
8	Sesbania	Polymeria takeall	Barnyard grass
9	Bathurst burr	Noogoora burr	Bathurst burr
10	Nutgrass	Sesbania	Hairy wandering jew
11	Liverseed grass	Bathurst burr	Mint weed
12	Thornapple	Barnyard grass	Anoda weed
13	Grey rattlepod	Blackberry nightshade	Polymeria takeall
14	Haloragis takeall	Liverseed grass	Sow thistle
15	Ryncho		Liverseed grass

Nearly all these troublesome weeds were amongst the more numerous weeds observed in the physical survey. Cow vine, for example, was one of the top two weeds in both the physical survey and growers' nominations on each occasion (compare Tables 1 and 3). Nutgrass, which rose from minor importance in the physical survey in 1992 to major importance in 1996 and 2001, was considered by growers to be the most troublesome weed by 1996. By 2001, with the introduction of Roundup Ready cotton which allows much better in-crop control of this weed, the perceived importance of nutgrass had declined. Hairy wandering jew was the only weed new to the survey in 2001. This weed was first observed in the 2001 physical survey and is likely to be a more important future problem as it is very difficult to control in the current farming system.

The weed management system

Managing weeds that are glyphosate tolerant and adapted to minimum tillage systems is difficult to achieve in the current cotton cropping system. Weed management in rotation crops can be particularly difficult. Cereals are the most common rotation crops, but many herbicides that are normally used in these crops (such as the sulfonyl ureas) can not be readily used due to plant-back constraints. This problem is exacerbated in many of the cotton growing areas where soil pH is high (pH 8 to 9.5), and rainfall is not reliable, sometimes leading to extended plant-back periods. Consequently, weeds are often not adequately controlled in rotation crops.

Similarly, weed management in fallows often receives insufficient attention, with some small weeds allowed to grow and set seed before being controlled. This may occur for a variety of reasons, including labour shortages at critical times, and dry conditions making it difficult to

control moisture-stressed weeds with herbicides. The general response to weed escapes has been to use higher rates of glyphosate and to tank-mix a second herbicide such as 2,4-D amine where possible. However, these strategies are not always successful. Resistance to glyphosate is an ever present threat, with cases of glyphosate resistant ryegrass already reported from numerous properties in the general cotton production area. Although no case of herbicide resistance has yet been detected on a cotton field, it is inevitable that resistance will occur. Tank-mixing with other herbicides has been a useful strategy, but often results in reduced herbicide efficacy due to herbicide antagonism, and has led to many cases of crop damage from herbicide residues. Plant-back periods to cotton are prohibitively long for many of the alternative herbicides of choice.

Integrated weed management (IWM)

To overcome these problems of weed pressure, changes in the weed spectrum, and herbicide resistance, cotton growers need to develop a more proactive, integrated approach to weed management, combining a variety of weed management tools into a dynamic system that ensures, that all weeds are managed as some point in the cropping system, ultimately reducing the size of the weed seed bank, and decreasing weed pressure. Components of an integrated weed management (IWM) system must include crop agronomy and management, irrigation management, strategic cultivation and hand hoeing, as well as herbicides[1]. Cotton growers need to be more vigilant in monitoring weed populations, and ensuring the timeliness of field operations, so that weeds escapes are not allowed to set seed at any point in the seasonal cycle. Spray-topping to sterilize seed should be considered as a last resort.

The problem of weed management in rotation crops should be addressed to ensure that weed seed return to the seed bank is reduced in all phases of the rotation. More emphasis should be placed on crop competition, using tools such as more vigorous varieties, increased planting rates, and fertilizer placement. Alternative herbicide strategies should also be considered. Prometryn, for example, is registered for broadleaf weed control in wheat, barley and lucerne and has no plant-back limitations to cotton.

Weed management on irrigation structures and in fallows should be given more emphasis, ensuring that no weeds are allowed to set seed. Areas such as irrigation structures, where weeds are being primarily controlled with glyphosate, are primary sites for the development of glyphosate resistant weeds. The emergence of volunteer Roundup Ready cotton plants and fleabane as major weed problems on many irrigation structures highlights the importance of developing alternative weed management strategies for these structures. The use of alternative herbicides such as 2,4-D and amitrole should be considered, together with options such as mechanical control, slashing and establishing competitive, non-invasive plants on these areas.

Developing an effective IWM system is not simple, but will ensure the sustainability of the reduced tillage system and bring long-term benefits as weed seed banks and weed pressure are reduced.

Acknowledgements

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[1] The tools to develop an IWM program are well covered in WEEDpak, available from one of the authors or through David Larson at the Australian Cotton CRC Technology Resource Centre at ACRI, Narrabri. Phone: 02 6799 1534, or email: david.larson@agric.nsw.gov.au